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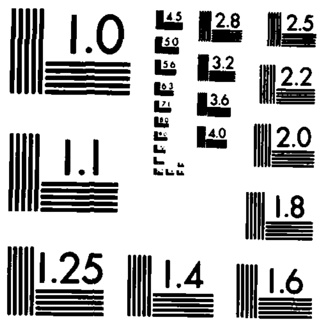

MICROCOPY RESOLUTION TEST CHART
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Results have been obtained for certain second order hyperbolic systems with viscous dumping which imply that one can increase "at will" the margin of stability of arbitrarily finite modes of the damped wave equation (those presumed "dominant") by means of certain type of boundary feedback, while the remaining new modes approach asymptotically the original ones from the left of the vertical axis Rez = -k. Numerical testing of the constructive procedure is in the process of being implmented by a Ph.D. student.

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Progress Report

Reference is made to the Original Proposal (O.P.) which was submitted to the A.F.O.S.R. on January 1984. The grant's official starting date is September 1, 1984.

Of the two canonical problems for second order hyperbolic dynamics with viscous damping, which were proposed in Section 2 of the O.P., we have so far obtained a theoretical solution of the first (case 1, p 3 of O.P.). Our argument is essentially constructive, and this lends itself naturally to numerical algorithms. Numerical testing is about to begin soon.

More precisely: consider the following boundary feedback for the damped wave equation

(1) $x_{tt}(t,\xi) = \Delta x(t,\xi) - 2kx_t(t,\xi)$ in $(0,\infty) \times \Omega$

I.C. x_o and x_1 in Ω

(2) $x(t,\sigma) = [\langle x(t,\cdot), w_1\rangle + \langle x_t(t,\cdot), w_2\rangle]\, g(\sigma)$ in $(0,\infty) \times \Gamma$

Here $k > 0$ is the coefficient of viscous damping and the right hand side of (2) is the "interior observation" acting on the boundary.

For $g = 0$ and 'small' $k > 0$, the eigenvalues $\lambda^{+,-}_m$ of the <u>free</u> system lie on the vertical line

Re $\lambda = -k$ and it is a classical result that all free solutions decay with upperbound e^{-kt} in the energy norm for $t > 0$.

For $g \neq 0$, the following result is proved in [L-T.5], [T.4].

Let a <u>real</u> $g \in L_2(\Gamma)$ be given, with $(g_{ext}, e_m)_{L_2(\Omega)} \neq 0$, m=1,2,... where g_{ext} = harmonic extension of g onto Ω and $\{e_m\}$ are the eigenvectors of the Laplacian Δ with zero Dirichlet B.C. Let an arbitrary sequence $\{\varepsilon^{+,-}_m\}$ of distinct, non zero complex numbers, with ε^+_m = complex conjugate of ε^-_m be given. It is assumed that, moreover, the sequence $\{\varepsilon^{+,-}_m\}$ satisfies some technical assumptions i.e. that a few infinite sums involving $\{\lambda^{+,-}_m\}$, $\{\varepsilon^{+,-}_m\}$ and (g_{ext}, e_m) be finite), which allow finitely many $\{\varepsilon^{+,-}_m\}_{m=1}^{M}$, M arbitrary, to be preassigned at will, while the sequence $\{\varepsilon^{+,-}_m\}$ approach zero 'sufficiently fast'.

Then, one can construct <u>real</u> vectors $w_i \in L_2(\Omega)$ i = 1,2, such that the feedback system (1)-(2) has the following two ' ;irable properties:

(i) its eigenvalues $\{\alpha^{+,-}_m\}$ are given precisely by $\alpha^{+,-}_m = \lambda^{+,-}_m + \varepsilon^{+,-}_m$ (so that any finitely many

$\{\alpha_m^{+,-}\}$ can be preassigned at will, while the distance $|\alpha_m^{+,-} - \lambda_m^{+,-}|$ between new and original eigenvalues goes to zero);

(ii) its corresponding eigenvectors form a Riesz basis on $L_2(\Omega) \times H^{-1}(\Omega)$.

In particular, we may require Re $\varepsilon_m^{+,-} < 0$, in which case all feedback closed loop solutions preserve the overall decay upper bound e^{-kt}, $t > 0$, in view of properties (i) - (ii). This result, in particular, implies that one can increase at will the margin of stability of arbitrarily finite modes of the damped wave equation (those presumed 'dominant') by means of the boundary feedback in (2), while the remaining new modes approach asymptotically the original ones from the left of the vertical axis Re $\lambda = -k$.

Numerical testing of the procedure, which is essentially constructive is in the process of being implemented by a Ph.D. student, G. Bartolomeo. Thus, the short term goal of the Project Summary of the Original Proposal has been accomplished.

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